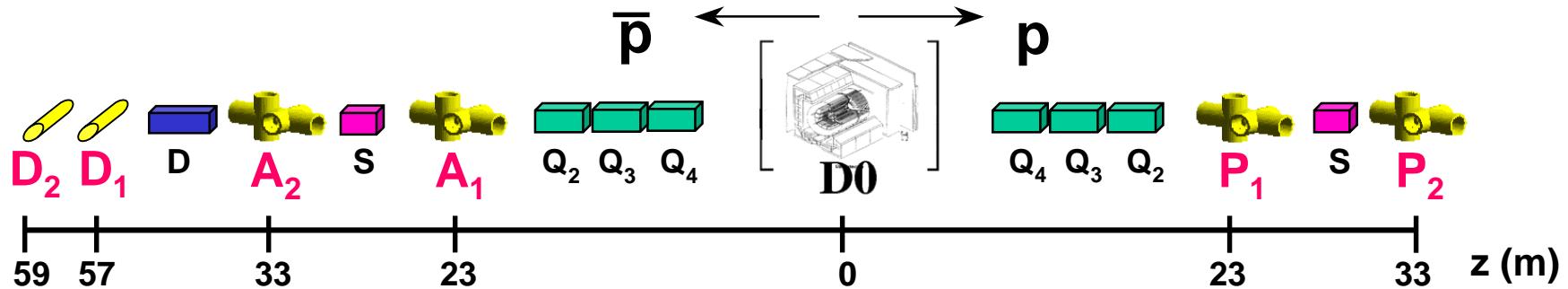


# FPD Trigger

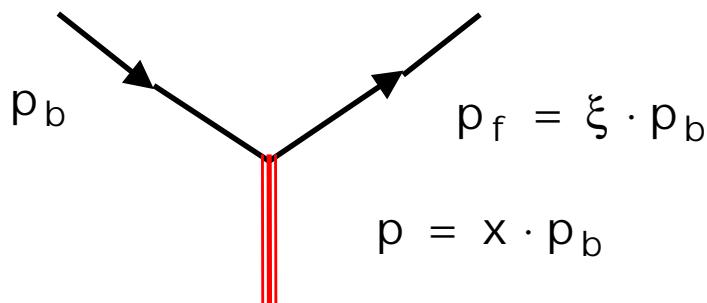
*M. Martens*

- ❑ FPD Hardware Layout
- ❑ Trigger Strategy
- ❑ Trigger and DAQ Electronics
- ❑ Standalone Trigger
- ❑ L1 Objects: hits and tracks
- ❑ Halo and Multiple interactions
- ❑ L3 Tools
- ❑ FPD Trigger List



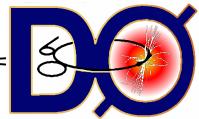
18 Roman Pots = 1 Dipole Spectrometer + 8 Quadrupole Spectrometer

measurement of proton momentum and angle:



$$\xi = 1 - x$$

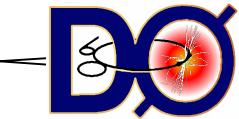
$$t = (p_b - p_f)^2$$



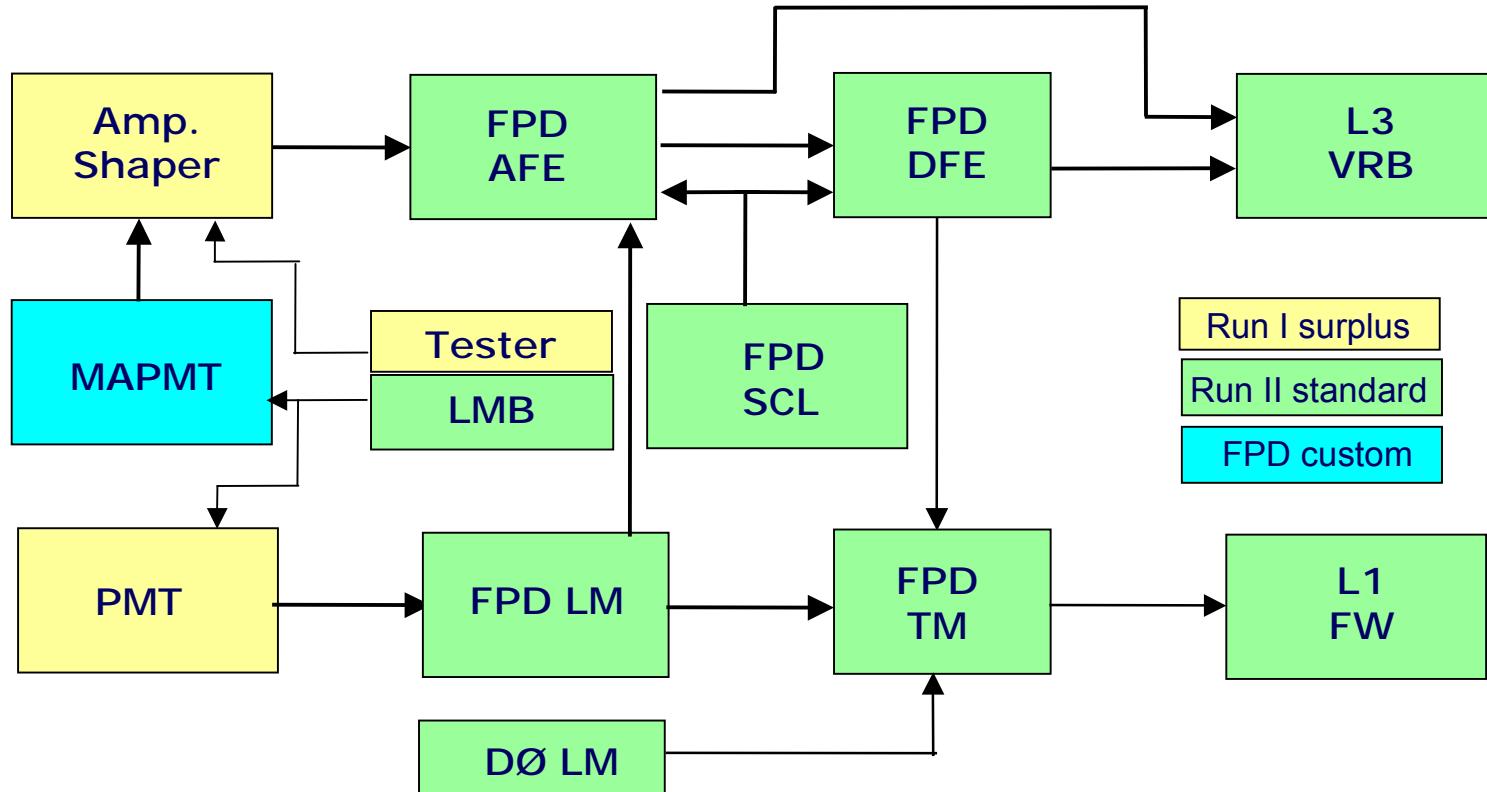
# Trigger Strategy

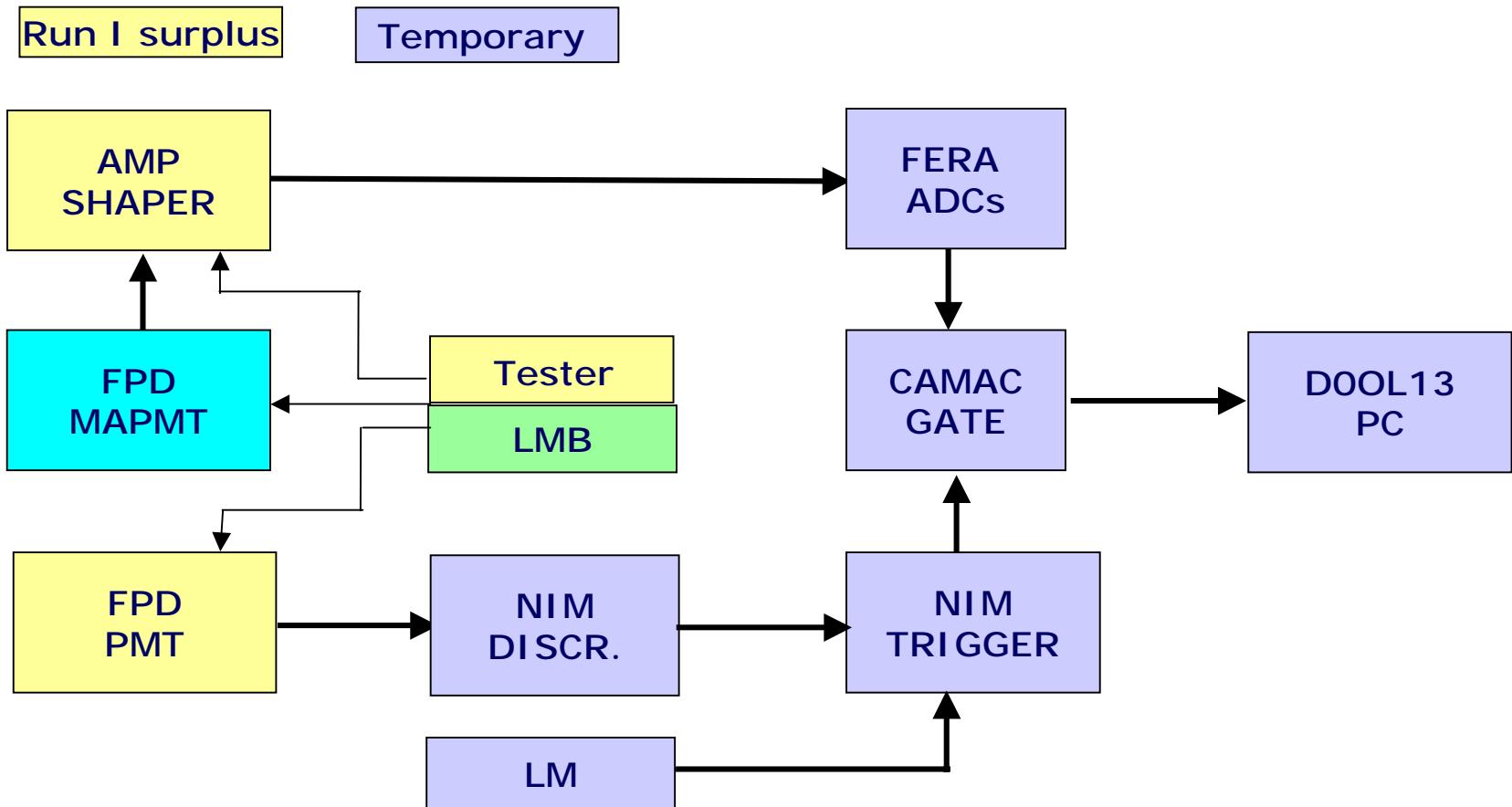
- ❑ No special conditions required
- ❑ Read out Roman Pot detectors for all events
- ❑ Some dedicated global triggers for diffractive jets, double Pomeron, and elastic.
- ❑ Use Central Tracking Trigger system (AFE, DFE & TM)
  - Allows selection of  $x$ ,  $|t|$  ranges at L1
  - Readout DØ standard
- ❑ Reject fakes from multiple interactions (SD + dijet) using vertex, momentum, and LM information
- ❑ Obtain large samples (for  $1 \text{ fb}^{-1} = \text{Run2a}/2$ ):
  - ~ 1K diffractive W bosons
  - ~ 3K hard double Pomeron
  - ~ 500K diffractive dijets

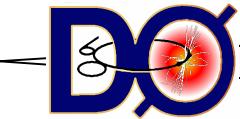
with minimal impact on standard DØ physics program



# Trigger and DAQ Electronics







## ❑ FPD Tracks

- HIT = Coincidence between U and V planes confirmed by a X plane
- Track = Two HIT's in a spectrometer (2 pots) constrained to DØ IP.

## ❑ Halo `Track`

- Early-time hits in trigger scintillator before crossing
- Possibly in 'coincidence' with in-time hits in opposing spectrometer.

## ❑ Input to FPD Trigger Manager:

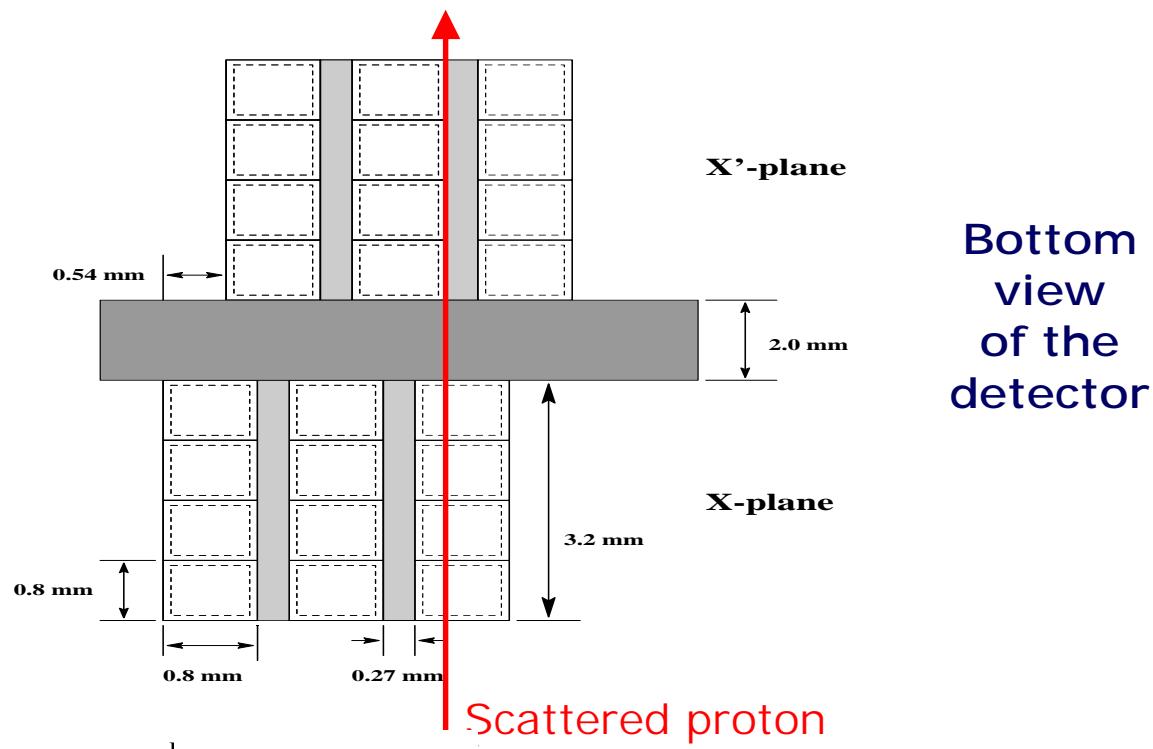
- Number of hits and  $\xi$  and  $|t|$  range of the tracks
- Timing of the tracks (in-time or halo)
- LM information

## ❑ Input to L1 FrameWork:

- List of valid AND/OR terms
- $|t|$ ,  $\xi$  and Halo cuts

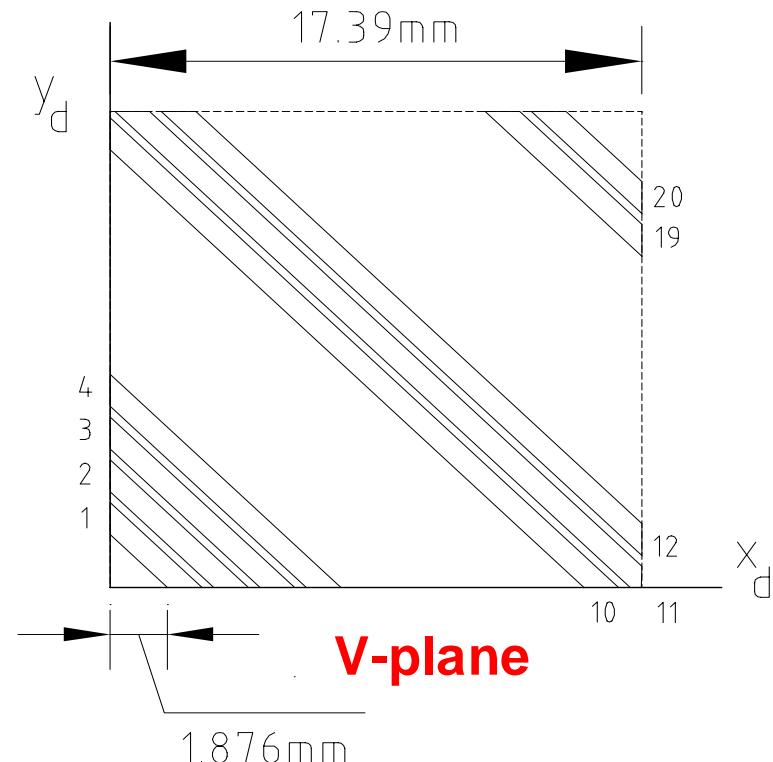
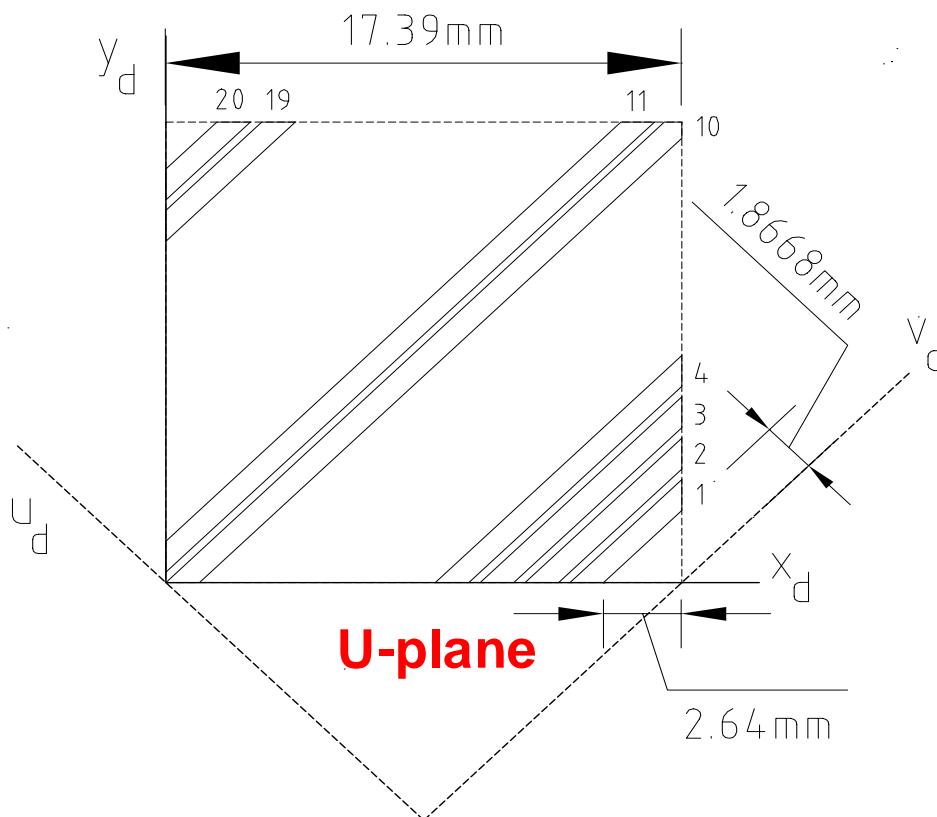
PLANE (U, V, X) : Two layers of parallel fibers offset by 1/3 fiber width

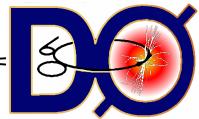
20 + 20 fibers  
= 79 possible  
HIT values  
with 0.27 mm  
resolution



Bottom  
view  
of the  
detector

- U and V planes are oriented at  $\pm 45^\circ$
- U-hit & V-hit determines **position** of a track: 4,128 possible combinations
- Signals in X and X' layers used for **confirmation**, ghost hit elimination, and to measure fiber hit efficiency.





# FPD Detector Track

- ❑ A **TRACK** is determined from the positions in two FPD detectors: straight line, with small correction for electrostatic separators quadrupoles
- ❑ There are  $(4,128)^2 \sim 17\text{ M}$  track combinations (equations)  
Only some are consistent with origin at the IP.
- ❑ Adding DØ IP as constraint:
  - Determines momentum and scattering angle ( $p, \theta$ )
  - Reduces number of equations to  $\sim 500\text{ k}$
- ❑ Use ranges of  $(\xi, |t|)$  to reduce number of equations
  - Reducing resolution for high  $|t|$  to 1 fiber:  $\sim 50\text{ k}$
  - One FPGA (Virtex 2000) per spectrometer
  - Three spectrometer per double-wide DFE: 3 DFE's

Particle trajectory with respect to the beam is determined from

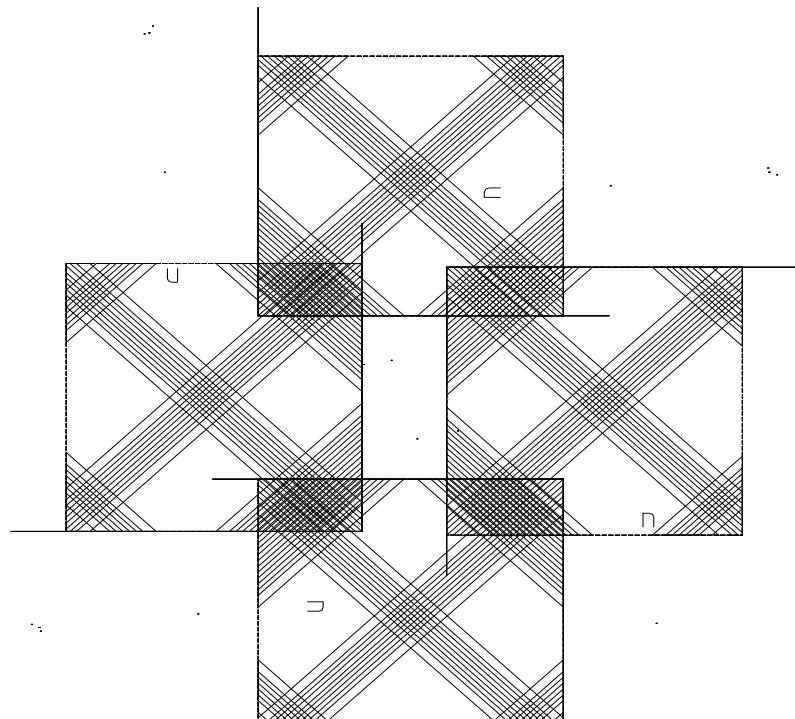
- FPD detector ( $x, y$ ) position (100  $\mu\text{m}$  resolution)
- Pot position ( $\sim 8 \mu\text{m}$  with step motor count)
- Surveying wrt beamline ( $\sim 10 \mu\text{m}$ )
- Beam orbit ( $\sim 20 \mu\text{m}$  with collision point type BPM's)

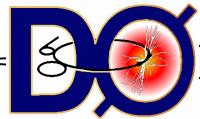
Calibration run can improve accuracy.

Separators off and no low beta  
squeeze: detectors overlap.

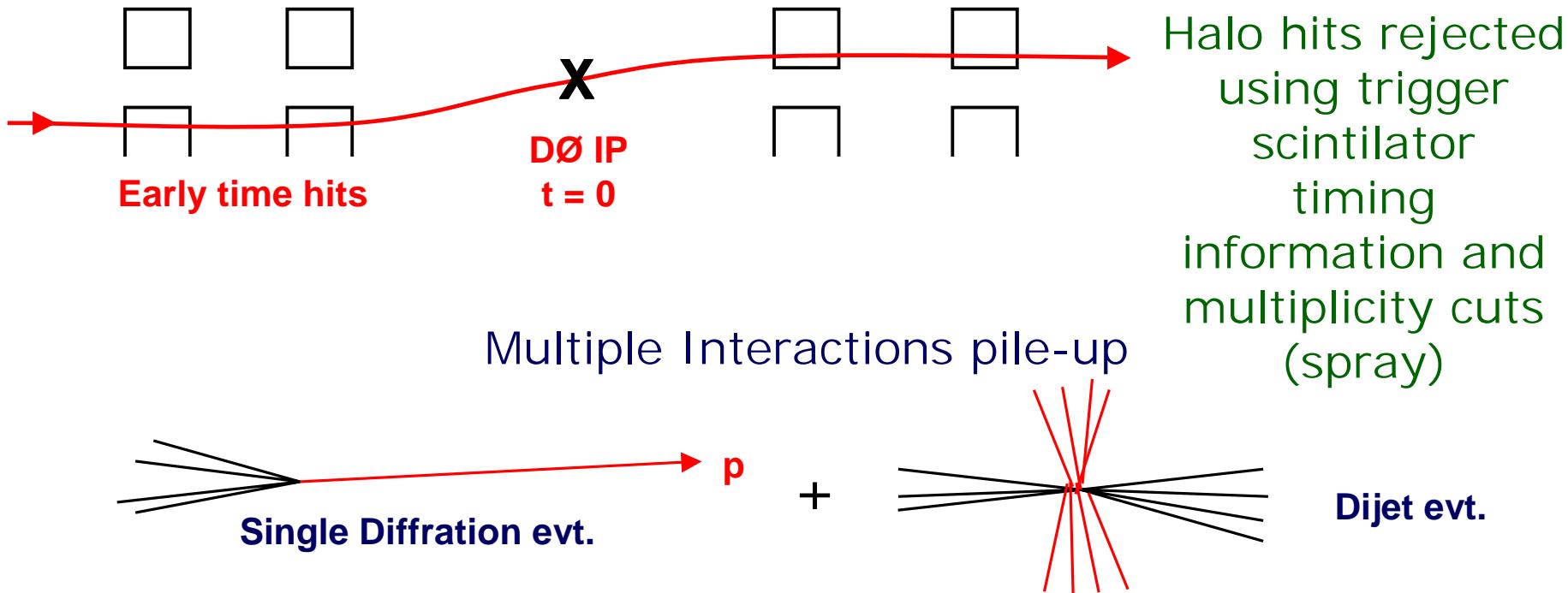
This one time run allows the relative  
position of the detectors to be  
determined

- Need to know position in a run-by-run basis +
- Accel. parameters: magn.  
current, sep. voltage, etc.
- Calibration Database





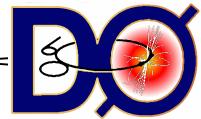
- ❑ The FPD PMT signals will be passed to LM boards using high quality flexible cables
- ❑ Signals processed like LM signals except for timing
- ❑ Use timing information to veto/accept events whose signal arrives before/after the crossing (halo/in-time)
- ❑ The LM control board provides two nine-bit words to the FPD\_TM: halo bit set OR coincidence bit set.
- ❑ Vertex position and a pile-up bit combining LM + FPD info under study  
(Pileup noise: Soft Diffraction + Hard Interaction)



Large for quadrupole (low  $\xi$ ) and small for dipole (high  $\xi$ )

Level 1 cut on  $\xi$  reduces overlap

Level 3 Single Interaction tool could further reduce pile-up



# L3 Single Interaction Tool

We can use information from other detectors:

## Silicon Tracking

Reject events with 2 central vertices with  $|z| < 30$  cm at L3

Above given probability of a secondary vertex event is rejected

## Calorimeter

Require conservation of longitudinal momentum

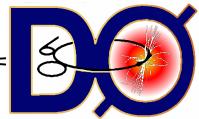
Information from FPD track Reco and Calorimeter unpacking:

$E_{\text{Diff. Trigger part.}} + E_{\text{(Deposited @ DØ Cal.)}} < 1 \text{ TeV}$

## Luminosity Monitor

LM information helps with non-central vertex

Can use event interaction time / multiplicity



Two possible strategies:

- Arrival time in both hemispheres (South & North)

$$\text{Sigma T: } (\Delta T_{\text{South}}^2 + \Delta T_{\text{North}}^2)^{1/2}$$

$$\text{Largest T: } \text{Max}(\Delta T_{\text{South}}, \Delta T_{\text{North}})$$

- Multiplicity of the event

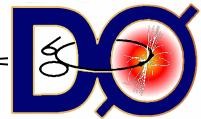
$$\text{Hit Sum: } N_{\text{south}} + N_{\text{north}}$$

$$\text{Hit Asymmetry: } |N_{\text{south}} - N_{\text{north}}| / (N_{\text{south}} + N_{\text{north}})$$

$$\text{Less Hits: } \text{Min}(N_{\text{south}}, N_{\text{north}})$$

$$\text{Hit Product: } N_{\text{south}} \cdot N_{\text{North}}$$

Multiplicity more efficient than Time



# FPD Triggers

16 AND-OR terms to implement all FPD triggers

- RTK(1) :  $x > 0.99$ , all t
- RTK(2) :  $0.99 > x > 0.9$  all t
- RTK(3) :  $x > 0.9$  all t, no halo veto
- RTK(4) :  $x > 0.9$ ,  $|t| > 1 \text{ GeV}^2$
- RTK(5) :  $x > 0.9$ , all t
- RPT(1) :  $x > 0.99$ , all t
- RPT(2) :  $0.99 > x > 0.9$  all t
- RAT(1) :  $x > 0.99$ , all t
- RAT(2) :  $0.99 > x > 0.9$  all t
- REL(1) :  $x > 0.99$ , all t
- REL(2) :  $x > 0.99$ ,  $|t| > 1 \text{ GeV}^2$
- ROV(1) :  $x > 0.90$ , all t
- ROV(2) :  $x > 0.90$ ,  $|t| > 1 \text{ GeV}^2$ )
- LMO : no hits in LM
- LMI : Single Interaction
- LMD : N + Sbar .OR. S + Nbar

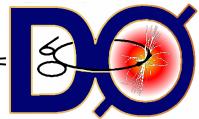
RTK = track in any spectrometer, (D = veto on halo)

RPT = proton track

RAT = anti-proton track

REL = Elastic (diagonally opposite p and  $\bar{p}$ )

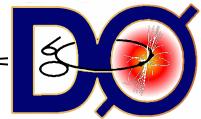
ROV = Over-constrained track (D+Q proton tracks)



# FPD Trigger List

	Name	L1-2 Name	L1 TRIGGERS
1	PRO_SDJT_MXHI	RTK_H_JET_SI	RTK(2) CJT(2,2) LMI(1)
2	PRO_SDJT_MXLO	RTK_L_JET_GAP	RTK(1) CJT(2,2) LMD
3	PRO_SDJT_MI	RTK_JT	RTK(5) CJT(2,2)
4	PRO_DPJT	RTK_2H_JET_SI	RPT(2) RAT(2) CJT(2,2) LMI(1)
5	PRO_DPTK	RTK_2H_TTK_SI	RPT(2) RAT(2) LMI(1) TTK(1,1.5)
6	PRO_DP_MHMON	RTK_2H	RPT(2) RAT(2)
7	PRO_DP_INC	RTK_2L_TMO	RPT(1) RAT(1) LMO RELbar TMO
8	PRO_DP_IMON	RTK_2L	RPT(1) RAT(1) RELbar
9	PRO_SD_INC	RTK	RTK(5)
10	PRO_SD_HALMON	RTK_NHL	RTK(3)
11	PRO_SD_HIT	RTK_HT	RTK(4)
12	PRO_SD_OVER	ROVH	ROV(1)
13	PRO_ELASTIC	ELAS	REL(1) LMO

FPD				
RTK(x)	FPD tracks	x=p range	x=5 values	5 terms
RPT(x)	FPD proton Quad Tracks	x=p range		2 terms
RAT(x)	FPD Anti-proton Quad or Dipole Track	x=p range	x=4 values	2 terms
REL(x)	FPD elastic	x=p range	x=2 values	2 terms
ROV(x)	FPD Overconstrained track	x=p range	x=2 values	2 terms
Spares				3 terms
				16 terms



# FPD Triggers

1. Hard Diffraction: High  $M_X$
2. Hard Diffraction: Low  $M_X$
3. All  $M_X$
4. Hard double Pomeron + jets
5. Hard double Pomeron + tracks
6. Double Pomeron (no SI) monitor
7. Inclusive p-pbar + hits in CFT
8. Inclusive p-pbar monitor
9. Inclusive Single Diffraction ( $M_X$ )
10. Inclusive Single Diffraction halo
11. Inclusive Single Diffraction high  $t$
12. Over constrained track
13. Elastic